CHAPTER 10. NATIONAL ENERGY IMPACTS AND REGULATORY IMPACT ESTIMATES

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CHAPTER 10. NATIONAL ENERGY IMPACTS AND REGULATORY IMPACT ESTIMATES

10.1 INTRODUCTION

This chapter describes the method for estimating the quantity and value of future national energy savings (NES) from possible standards and other regulatory actions and options. The NES is one of the metrics for evaluating the standard impacts, while the examination of other regulatory options is referred to as the regulatory impact analysis (RIA). The two metrics discussed in this chapter are:

- National Energy/Water Savings (section 10.2), and
- Net Present Value (NPV) of Energy/Water Savings (section 10.3).

All calculations are performed on a series of Microsoft Excel spreadsheets which are accessible over the Internet. Basic outputs from the spreadsheet calculations are discussed in section 10.4. A more detailed set of results is available in Appendix N. Access to and basic instructions for the spreadsheets are discussed in section 10.5.

10.1.1 Methodology and Definitions

The methodology applied to the national energy and water savings and the regulatory impact estimates includes detailed calculation of both baseline and regulatory scenarios for sales, energy, water use, and appliance purchase expenses. There are several interrelated factors that can affect appliance purchase expenses, and energy and water savings. These factors include changes in purchase price caused by the promulgation of standards, price-induced changes in consumer purchase behavior, differences in energy and water consumption rates for clothes washers with different efficiencies and the concomitant differences in operating cost. Performance standards and regulatory interventions can change both purchase behavior and the mix of appliance efficiencies that are in the market. These purchase changes then result in changes in the age distribution and mix of efficiencies and resource consumption rates of household appliances.

The NES and RIA impact models consist of two main components: The first component is a shipments model that provides the accounting of both sales, and clothes washers stocks for different efficiency and age categories of clothes washers. The shipments model estimates the number of clothes washers of each age and each efficiency category for each year of interest. The second component of the NES and RIA calculations is a net cost/benefit calculation of the relative costs and savings of the standard, regulatory and baseline scenarios.

The NES and RIA calculations are presented in an integrated Excel spreadsheet that provides results in both tabular and graphical form along with presentation of the overall evaluation metric for the scenarios. These metrics include the net present value of the energy and water savings, the benefit/cost ratio of the resource savings, the net cumulative volumetric water savings, and the energy savings for each fuel type[a] for each decade.

10.2 NATIONAL ENERGY/WATER SAVINGS (NES)

10.2.1 Definition

This section provides the definition of national energy savings.

National annual energy savings are calculated as the difference between two projections: a base case (without new standards) and a standards case. Positive values of NES correspond to energy savings, that is, energy consumption with standards is less than energy consumption in the base case.

$$NES_y = AEC_{base} - AEC_{standard} \qquad \textbf{Eq. 10-1}$$

Cumulative energy savings are the sum over some period (e.g., 2000-2030) of the annual national energy savings.

$$NES_{cum} = \sum NES_y \qquad \textbf{Eq. 10-2}$$

The national annual energy consumption is calculated according to the following equation:

$$AEC = \sum STOCK_V * (UEC_V * n_{cycle}) \qquad \textbf{Eq. 10-3}$$

The national water consumption is calculated according to the following equation:

$$AWC = \sum STOCK_V * (UWC_V * n_{cycle}) \qquad \textbf{Eq. 10-4}$$

where the different quantities are defined as follows:

AEC = Annual energy consumption each year (Quads), summed over

[a]Water heaters or clothes dryers may use one of several fuel types (e.g. electricity, natural gas, LPG (propane), and--for water heaters--distillate oil).

vintages of clothes washer stocks, $STOCK_V$.

AWC = Annual water consumption each year (10^3 gallons), summed over vintages of clothes washer stocks, $STOCK_V$.

n_{cycle} = Cycles per year (e.g., loads of laundry)

NES = Annual national energy savings (Quads)

$STOCK_V$ = Stock of clothes washers (millions of units) of vintage V surviving in the year for which annual energy consumption is being calculated. Vintages range from 0 (new)- to 23-years old.

UEC_V = Energy consumption per clothes washer per cycle (kWh electricity, MMBtu gas or oil). (NOTE: electricity consumption is converted from site energy (kWh) to source energy (Quads) by applying a time dependent conversion factor (Btu/kWh). See quantity "src_conv" below in discussion of AEC.)

UWC_V = Water consumption per clothes washer per cycle (gallons per cycle)

V = Year in which the washer was purchased as a new unit.

y = year in the forecast (e.g., 2000-2030)

10.2.2 NES Inputs

This section provides information about the quantities and assumptions used to calculate national energy/water savings for clothes washer standards. For each quantity, the discussion includes:

- definition
- approach
- current assumption

The inputs into the NES analysis are listed in the table below.

Table 10.1 National Energy/Water Saving Inputs

Input
National Annual Energy Consumption (AEC)
National Annual Energy Savings (NES)
Source conversion factor (src_conv)
Stock of clothes washers ($STOCK_V$)
Cycles per year (n_{cycle})
Energy per Cycle (UEC)
Water per Cycle (UWC)
Shipments
Effect of Voluntary Programs

10.2.2.1 Annual Energy Consumption (AEC)

Definition. National energy consumption associated with residential clothes washers and dryers.

Approach. National energy consumption is the product of energy consumption per washer times the number of clothes washers of each vintage. This approach accounts for differences in unit energy consumption from year to year. Annual energy consumption per clothes washer is calculated as the product of energy per cycle times number of cycles per year.

$$AEC = \sum STOCK_V * (UEC * n_{cycle}) \qquad \textbf{Eq. 10-5}$$

Current Assumptions. Energy consumption is calculated at the site (e.g., electricity in kWh consumed in the household). Primary energy consumption is calculated from site energy consumption by applying a conversion factor to account for losses, such as losses in generation, transmission and distribution of electricity. See *Source Conversion Factor*, below.

10.2.2.2 National Energy Savings (NES)

Definition. Energy savings attributable to the new standards.

Approach. Energy savings are calculated as the difference between projected energy consumption in the Base Case (having no new standards) and the projected energy consumption in the Standards Case.

Current Assumptions. Because the shipments model estimates small changes in the number of households with clothes washers, the base case and the standards case have a different number of residential clothes washers. To account for this effect, we assume that the households that change from owning a washer to not owning a clothes washer, are still washing their clothes using a clothes washer with average energy and cost characteristics. The average per unit cost/benefit, and energy characteristics of the clothes washer utilized by the non-owner (who was an owner in the base case scenario) is assumed to be the same as that for user-owned residential clothes washers. We therefore rescale the energy and cost estimates according to the relevant population of users. For the net present value calculation (NPV) we scale the costs and benefits to correspond to the population of residential users who are benefitting directly from the more efficient machines. This means that for NPV, costs are scaled to correspond to the standards case. Meanwhile, for the national energy savings calculation, we assumed that those who are using common area washers or laundromats are using machines with the same efficiency as the residential clothes washers. This means that we scale the savings to correspond to the population of households in the base case. In the most extreme case, the change in the number of households owning clothes washers is less than 4%, but the adjustment in the calculation is necessary for computational accuracy.

10.2.2.3 Source Conversion Factor (src_conv)

Definition. For electricity, this is the factor by which site kWh is multiplied to obtain primary (source) Btu. The source conversion factor accounts for losses in generation, transmission and distribution. For natural gas, this is the loss in transmission and distribution.

Approach. After calculating energy savings at the site, multiply those site energy savings by a conversion factor to obtain primary energy consumption, usually expressed in Quads (quadrillion Btu). This conversion permits comparison across fuels by taking account of the heat content of different fuels and the efficiency of different energy conversion processes.

Current Assumptions. The source conversion factor is applied to site electricity, to convert from site kWh to source Btu. This analysis assumes that the source conversion factor changes over time, and applies annual values. The annual values for each fuel type are the U.S. average conversion factors, calculated from AEO99, Table A4.[1]

For the source conversion factors, DOE uses the following method:

(1) From the NEMS Annual Energy Outlook reference case, the source energy consumption is extracted.
(2) An energy savings scenario is input into NEMS (specifically a deviation from the reference case) to obtain the corresponding source energy consumption.
(3) The difference in source energy consumption between the energy savings scenario and the reference case is calculated.
(4) The source energy savings in Btu, adjusted for class specific transmission and distribution losses, is divided by the site energy savings in kilowatt-hours to provide the time series of conversion factors in Btu per kilowatt-hour.

Since NEMS can not adjust for class specific transmission losses, this information was obtained from sources outside of NEMS. For residential electricity customers, transmission losses might consist of about 3 percent (which basically gets you to a substation) and distribution losses may be about 7 percent (substation to house). For the above case, the conversion factor would be the marginal plant heat rate times 1.10. For natural gas, the transmission and distribution losses amount to about 10% of primary energy, so primary energy is calculated from site energy by dividing site energy by 0.90.

The resulting conversion factors change over time, and account for the displacement of generating sources. The National Energy Savings spreadsheet models includes a clearly defined column of conversion factors, one for each year of the projection.

10.2.2.4 Stock of Clothes Washers by Vintage ($STOCK_V$)

Definition. Number of user-owned clothes washers in U.S. households at the beginning of a particular year. The vintage is the age of the washer (1-year old up to 23-year old).

Approach. The NES spreadsheet keeps track of the number of clothes washers in U.S. households and the year in which they were purchased. This is done through the shipments model which is a dis-aggregated accounting model that keeps track of number of clothes washers in each age category.

Current Assumption. For clothes washers, lifetimes range from 11 to 17 years, with an average of 14.1 years (see section regarding the shipments model and the replacement/survival probability). Under scenarios of large purchase price increases, extended-life washers may have lifetimes as long as 23 years.

10.2.2.5 Cycles per Year (n_{cycle})

Definition. Loads of laundry washed per household per year.

Approach. The DOE test procedure assumes 392 cycles per year. In actuality, the number of loads of laundry washed per household per year depends upon the number of persons in the household, and probably on other factors.

Current Assumption. Assume an average of 392 cycles per year for all years.

10.2.2.6 Energy per Cycle (UEC)

Definition. Energy consumed per cycle.

Approach. In accordance with the DOE test procedure (for modified energy factor, MEF), energy consumption per cycle includes electricity used by the clothes washer, and energy used by the water heater to provide hot water, and energy used by the clothes dryer to dry the clothing.

The base case forecast of unit energy consumption is comprised of a weighted average of baseline efficiency level (MEF=0.817), a 35% energy reduction from baseline, MEF = 1.257 and a pre-baseline level (MEF = 0.760) that corresponds to machines purchased before the 1994 standard. The relative weight represents the relative market share of pre-1994, baseline and of horizontal axis machines that are expected in a baseline scenario. We assume that the market share of vertical axis machines will decrease by 0.5% each year in the baseline case and use this to project the market share of horizontal axis machines in the baseline case. The spreadsheet model also allows alternate assumptions of a 0.25% and 0.75% H-axis escalation rates.

For calculating the energy characteristics of the pre-baseline machine, we note that the minimum energy factor (EF) for clothes washers is 0.95 in 1988 compared to 1.18 for the EF for the baseline machine in this rule making. This implies that the pre-baseline machine uses 24.2% more energy in the motor and water energy component (which is the component of energy that the energy factor measures). Assuming that this energy increase relative to the current baseline is due solely to the increase in hot water energy, this implies that the pre-baseline machines use 0.435 kWh/cycle more hot water energy than the baseline machines. This implies 2.02 kWh of water energy for a pre-baseline machine and a 12% decrease of the MEF. The MEF for a pre-baseline machine is therefor set to 0.720 with engineering specifications set at the same as the baseline machine except for a 0.435 kWh/cycle increase in the hot water energy use component.

The unit energy consumption is composed of three components: water heating, machine (clothes washer), and dryer energy. Machine energy is electricity. Water heating energy depends upon the fuel type of the water heater. Dryer energy depends upon the fuel type of the dryer. (The DOE test procedure, Appendix J1 assumes a value based on an electric dryer; adjustments were made to this value for a gas dryer[2]).

The unit energy consumption is first calculated for an all-electric household, UEC^E. For each component (water heat, dryer, and machine), the weighted average is calculated, given the share of new washers that are horizontal axis.

Example: In 1998, 6.25% of new washers are assumed to have an efficiency equivalent to horizontal axis.

Table 10.2 Example of Average Electric Consumption for the Base Case

	Electricity (kWh/Cycle)		
Share	**Water Heater**	**Machine**	**Dryer**
93.75% (Baseline)	1.587	0.209	1.430
6.25% (Energy Efficiency equivalent to H-Axis)	0.462	0.133	1.270
Weighted average	1.517	0.204	1.420

The average electricity consumption per new clothes washer depends upon the shares of fuels for water heating and for clothes drying. The electricity consumed for water heating (calculated in the example above) is multiplied by the percent of households having electric water heating, then summed together with the product of electricity per unit for dryer times percent of households having electric dryers. Finally the machine energy per unit is added. The result is multiplied by cycles per year.

$$UEC^{E} = (kWh^{WH} * \%WH^{E}) + (kWh^{DR} * \%DR^{E}) + kWh^{machine} \qquad \textbf{Eq. 10-6}$$

Example: Continuing with the example for year 1995,

$$\begin{aligned} UEC^{E} &= (1.517 * 0.42) + (1.420 * 0.79) + 0.204 \\ &= 0.637 + 1.122 + 0.204 \\ &= 1.963 \text{ kWh/cycle} \end{aligned}$$

Annual energy consumption is the product of number of cycles per year and unit energy consumption per cycle. In the example for year 1998, $AEC^{E} = n_{cycle} * UEC = 392 * 1.963 = 769$ kWh/year.

Energy consumption for natural gas and for oil are obtained by correcting for the difference in recovery efficiency of the water heater, and by converting units from kWh to MMBtu. For natural gas, energy consumption per cycle for water heating (expressed in MMBtu) is:

$$(kWh^{WH} / 0.75) * (3412 \text{Btu/kWh}) / (1{,}000{,}000 \text{ Btu/MMBtu}),$$

where the denominator, 0.75, is the recovery efficiency of the gas water heater.

For distillate oil and LPG, energy consumption per cycle for water heating (expressed in MMBtu) is:

$$(kWh^{WH} / 0.81) * 0.003412 \text{MMBtu/kWh},$$

where the denominator, 0.81, is the recovery efficiency of the oil water heater.

Gas consumption for clothes dryer is:

$$(kWh^{DR}/0.89)*(3412Btu/kWh)/(1{,}000{,}000\ Btu/MMBtu),$$

where 0.89 is the efficiency of a gas clothes dryer.[3, 4]

Current Assumptions. Each of the components of energy consumed per cycle is obtained from the data submitted by AHAM, for baseline and for each of the efficiency levels. The percent of households having water heaters of each fuel type and having clothes dryers of each fuel type is fixed at the RECS 1993 levels for the period of the forecast. The fuel-type market shares are used to calculate the annual energy consumption for each fuel type. A weighted average unit energy consumption for new clothes washers (including water heat, clothes drying, and machine energy) is calculated for each year of the projection, according to the historical and forecasted market shares of the different efficiency levels. For standard levels below 1.257 MEF (35% level), it is assumed that the market share of standard level machines is the same as that of baseline machines in the base case scenario. The rest of the machines are assumed to be horizontal axis machines represented by the energy and cost characteristics of the 1.257 MEF level machines.

10.2.2.7 Annual Water Consumption (AWC)

Definition. National water consumption associated with residential clothes washers.

Approach. National water consumption is the product of water consumption per washer times the number of clothes washers of each vintage. This approach accounts for differences in unit water consumption from year to year. Annual water consumption per clothes washer is calculated as the product of water per cycle times number of cycles per year.

$$AWC = \sum STOCK_V * (UWC * n_{cycle}) \qquad \textbf{Eq. 10-7}$$

10.2.2.8 Water per Cycle (UWC)

Definition. Water consumed per cycle.

Approach. Similar to the calculations for the energy use per cycle, the base case forecast of unit water consumption is comprised of a weighted average of baseline water use and water use at the 1.257 MEF (35% reduction in energy use level).

Current Assumptions. The water consumed per cycle is obtained from the data submitted by AHAM, for baseline and for each of the efficiency levels (Note: The efficiency characteristics of the baseline machine is a weighted average of vertical axis machines that would be produced without a standard). A weighted average unit water consumption for new clothes washers is calculated for each year of the projection by taking a weighted average of horizontal-axis and vertical-axis machine characteristics, using the horizontal axis market share projection that is selected by the user.

10.2.2.8 Clothes Washer Shipments

Clothes washers shipments are obtained from a dis-aggregated clothes washer sales and stock accounting model that is described separately in chapter 9. The model is fully integrated with the cost and energy use scenarios in the National Energy Savings calculations. This means that when the user selects a scenario that changes the price or operating expenses of the clothes washers, this cost data feeds into the shipment forecast model to estimate changes in the stock and sales of different categories of clothes washers. This provides an estimate of feedback effects (e.g. the increased expense of more efficient clothes washers results in a decrease in sales which decreases the replacement rate of less efficient machines).

10.2.2.10 Voluntary Programs

A separate report describes voluntary programs already in place, which are promoting clothes washers with higher energy efficiency (see Appendix I).[5] The impact of these programs has been expressed here as the percent of new clothes washers each year that will have efficiencies corresponding to those of horizontal-axis washers (35% reduction in energy use from the baseline washer design).

The current spreadsheet provides the user with the opportunity to specify escalation rate of the market share increase of horizontal axis machines (relative to the base case washer design). This escalation rate is the relative amount that the market share of vertical axis machines will decrease each year. The escalation rate used for the reference base case scenario is 0.5% per year. This means that the relative market share of vertical axis machines is 99.5% of the market share for the previous year, starting with a market share of 6.25% for horizontal axis and 93.75% for vertical axis machines in 1998. This provides for a gradual, exponential decrease in vertical axis market share in the forecast. For illustrative purposes, Table 10.3 shows the values used in the draft spreadsheet.

Table 10.3 Percent of Annual Clothes Washer Shipments having Energy Consumption Equivalent to Horizontal Axis Washers

Year	Percent of shipments
1998	6.25%
2000	7.19%
2010	11.72%
2020	16.04%
2030	20.14%

10.3 NET PRESENT VALUE (NPV)

10.3.1 NPV Metric

NPV is the value in the present time (chosen as 1999 for this analysis) of a time series of costs and savings. Net present value is described by the equation:

$$NPV = PVS - PVC \qquad \textbf{Eq. 10-12}$$

where: PVS = present value of savings ("Total Fuel & Water Savings")

$$= \sum TotalOperatingCostSavings_y * DiscountFactor_y \qquad \textbf{Eq. 10-13}$$

PVC = present value of costs ("Net equipment Cost")

$$= \sum TotalEquipmentCost_y * DiscountFactor_y \qquad \textbf{Eq. 10-14}$$

y = Years (from start date of the valuation analysis)

The net present value is calculated from the projections of national expenditures for appliances, including purchase price and operating costs. Costs and savings are calculated as the difference between a new standards case and a base case without those new standards. Future costs and savings are discounted to the present.

A discount factor is calculated from the discount rate and the number of years between the "present" (year to which the sum is being discounted) and the year in which the costs and savings occur. The net present value is the sum over time of the discounted net savings.

Current Assumptions. The assumptions are contained in the terms PVC and PVS, which are discussed below. Net present value (NPV) is the value today of a future stream of savings less expenditures.

In the NES spreadsheet table labeled "Cost and Net Present Value," "Total Energy and Water Savings" is the present value of the savings. "Net equipment Cost" is the present value of increased purchase prices. "Net Present Benefit" is the difference between "Total Fuel and Water Savings" and "Net equipment Cost." "Benefit/Cost Ratio" is the ratio of "Total Fuel and Water Savings" to "Net equipment Cost."

10.3.2 NPV Inputs

This section provides information about the quantities and assumptions used to calculate net present value for clothes washer standards. For each quantity, the discussion includes:

- definition
- approach
- current assumption

Table 10.4 summarizes the inputs to the NPV calculation.

Table 10.4 Net Present Value Inputs

Input
Discount factor
Net equipment Cost_y
Total Operating Cost Savings_y

10.3.2.1 Discount Factor

Definition. The factor by which to multiply monetary values in one year, in order to determine the present value in a different year. Discount Factor is also described by the equation:

$$\text{Discount Factor} = 1/(1 + \text{DiscountRate})^{(\text{year - present year})} \qquad \textbf{Eq. 10-15}$$

***Approach*.** For example, to discount monetary values in the year 2001 to the value in year 1999, assuming a discount rate of 7% is $1/(1.07)^2$ or 0.873.

Current Assumptions. The discount rate is assumed to be 7% real.[a] For purposes of discounting dollar costs and savings, the present year is defined to be 1999.

10.3.2.2 Present Value of Costs (PVC)

Definition. Net equipment cost, discounted to the present, and summed over the time period (from start of standards to year 2030).

Approach. Costs are typically increases in purchase price associated with the higher energy

[a]Used by DOE in previous rulemaking for the National Impact Analysis. Higher and lower values can be used as sensitivities (i.e., to bound a range of discount rates).

efficiency of appliances purchased in the standards case compared to the base case. Costs are calculated as the difference in purchase price for new appliances purchased each year multiplied by the shipments in the standards case[a] ("Net equipment Costs").

Current Assumptions. The chief assumption made in calculating PVC lies in determining the discount factor to be applied. Here the discount rate is taken to be 7% (see *also Discount Factor*, above).

10.3.2.3 Present Value of Savings (PVS)

Definition. Annual operating cost savings (difference between base case and standards case) discounted to the present, and summed.

Approach**.** Savings are typically decreases in operating costs associated with the higher energy efficiency of appliances purchased in the standards case compared to the base case. The total operating cost savings is the product of savings per unit times number of units of each vintage surviving in a particular year. The operating costs savings are counted for only those households that own clothes washers in both the baseline and standards scenario. Appliances consume energy over their entire lifetime; therefore, we include the energy consumption after 2030 for those machines that are purchased new previous to 2030.

Net savings each year are calculated as the difference between Total Operating Cost Savings and Net equipment Costs.[b] The savings are calculated over the life of the appliance, accounting for the energy and water rates each year.

Current Assumptions. As with PVC, the chief assumption made in calculating PVS lies in determining the discount rate to be applied. Here the discount rate is taken to be 7% (see also *Discount Factor*, above). In addition, see *Net Equipment Cost* and *Total Operating Cost Savings*, below.

10.3.2.4 Net Equipment Cost

Definition**.** Annual change in purchase price (difference between base case and standards case), multiplied by shipments in the standards case.

Approach. Purchase price per clothes washer in the standards case is subtracted from

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[a]Counting the reduction in energy consumption from a reduction in shipments as a savings would be incorrect. If standards cause a decrease in shipments, then using the lower shipments in the standards case reduces the NPV appropriately. To illustrate with an extreme example, if standards cause shipments to be zero, then NPV is zero, no matter what the shipments were in the base case. Using the shipments from the standards case avoids miscounting any reduction in shipments due to standards as a savings.

[b] In the spreadsheet, Net equipment Costs are expressed as a negative number (the difference between the base case and the standards case) then summed with Total Operating Cost Savings (the difference between base case and the standards case).

purchase price per clothes washer in the base case for one year. The result is multiplied by the projected shipments in that year.

Current Assumptions. See appropriate TSD chapter for a discussion of shipments. As noted, a dis-aggregated accounting model is currently assumed to produce the best shipments forecast.

10.3.2.5 Total Operating Cost Savings

Definition. Annual national operating cost savings, calculated as the difference between total operating cost in the base case minus total operating cost in the standards case.

Approach. Under both the regulatory and baseline scenario the total energy and water use is calculated according to the engineering estimates for each vintage of clothes washer in stock. The average operating cost difference per clothes washer is then applied to the total stock of clothes washers in the standard scenario to calculate the total operating cost savings.

Current Assumptions. See *Cycles per Year and Energy per Cycle* as discussed in Sections 10.2.2.5 and 10.2.2.6, respectively, and the discussion of energy prices in Chapter 7.

10.4 OUTPUT FOR NES & NPV

The NES spreadsheets offer a range of possible outputs, all of which depend on the assumptions used in deriving the results. Table 10.5 details the assumptions used in the NES calculations in this analysis.

10.4.1 Assumptions

Table 10.5 Assumptions Used for Generating National Impacts

Fuel Price	EIA Annual Energy Outlook 1999 to the year 2020 and extrapolated to the year 2030
Water Price	Marginal: $2.49 per 1000 gallons
Discount Rate and the Year of the NPV	Discounted to the year 1999 (in 1997$) at 7 percent (real)
Start Year for New Standards	2004
Annual Real Change in Water & Sewer Cost (water price escalator)	2.96 percent
Manufacturing Cost	Shipment-weighted average of the most likely (cost estimate for each manufacturer from AHAM data)
Total Mark up on Manufacturer Costs	Obtained from Manufacturing Impact Analysis
Energy Consumption Data	AHAM data
Clothes Washer Shipments	Assumed same for standards and base case (inelastic to price and energy savings)
Percent Horizontal-Axis Washers	6.25 percent in 1998, with the relative market share of less efficient machines decreasing 0.5 percent each year
Primary Energy Conversion Factors	AEO99

Using these assumptions, we highlight output in key areas below.

10.4.2 Base Case Shipments

The results of the shipments model are used to establish a base case shipment forecast. The base case forecast is shown in section describing the shipments model.

10.4.3 National Energy Savings and Net Present Value from Possible Standards

The national energy savings and net present value results from the NES spreadsheet are shown in Tables 10.6 and 10.7. More detailed results are also available in Appendix N. Results are cumulative to 2030 and are shown as absolute energy and water savings and as the discounted value of these savings in dollar terms. Table 10.6 compares an upper and lower bound of consumer price sensitivity. The lower consumer price sensitivity case occurs if income is a factor in clothes washer purchases, while the higher consumer price response assumes that price is the primary explanatory variable for historical trends, and that the highest sensitivity consistent with historical data best represents future behavior. Specifically the lower bound is defined as price/income elasticity = medium; upper bound is defined as having a high price elasticity; all other parameters in the NES/Shipment spreadsheet are set at reference, medium or average.

The tables in this chapter use input values based on RECS93 and AEO1999 data. After this analysis was completed, the next issue of RECS and AEO data became available -- RECS97 and AEO2000. Results based on these data are provided in Appendix R. The most recent results do not vary significantly from the results based on RECS 93 and AEO2000.

Table 10.6 Range of Energy Savings and NPV for Each Standard Level

Trial Standard Level	MEF	Efficiency Improvement over the Base Case	Energy Savings Quads		Water Savings trillion gallons		Net Present Value (NPV) (billion 1997$)	
		Bound ⇨	lower	upper	lower	upper	lower	upper
1	1.021	20%	2.13	2.15	0.54	0.54	3.68	3.70
2	1.089	25%	4.08	4.06	9.17	9.14	14.40	14.32
4	1.257	35%	6.09	5.94	13.15	12.86	16.98	16.80
5	1.362	40%	6.13	5.98	13.15	12.85	16.83	16.66
6	1.634	50%	7.70	7.36	11.09	10.63	10.46	11.18
3	1.04 in 2004 1.26 in 2007		5.61	5.48	11.80	11.50	15.42	15.25

Table 10.7 Reference Case – All Parameters Set to Medium or Average

Trial Standard Level	MEF	Efficiency Improvement over the Base Case	Energy Savings Quads	Water Savings trillion gallons	Net Present Value (NPV) (billion 1997$)
1	1.021	20%	2.12	0.53	3.66
2	1.089	25%	4.04	9.09	14.29
4	1.257	35%	5.99	12.94	16.88
5	1.362	40%	6.03	12.94	16.73
6	1.634	50%	7.53	10.85	10.79
3	1.04 in 2004 1.26 in 2007		5.52	11.59	15.30

Table 10.7 shows the energy savings, water savings and net present value for different standard levels and the negotiated two-tier standard.

Table 10.8 summarizes the energy and water savings from the negotiated rule, and also provides an estimate of the present value of the incremental equipment cost.

Table 10.8 NES Results: proposed rule (MEF = 1.04 @ 2004 & MEF=1.26 @2007)

Cost and Net Present Values Discounted from 2004 at 7% real to 1997 (in billion 1997$)	
Total Energy & Water Savings	27.16
Net equipment Cost	11.86
Net Present Benefit	15.30
Benefit/Cost Ratio	2.3%

Table 10.9 details the cumulative energy and water savings at different years. The energy savings are also broken down by fuel type and illustrate how most of the savings is for electricity with major savings also in Gas consumption. The impact of the standard on Oil and LPG use is significantly smaller that the savings for Electricity and Gas.

Table 10.9 Efficiency Level: Energy and Water Savings (proposed rule)

	Energy Saving in Quads					Water Saving
	Total	Elec	Gas	Oil	LPG	(Trillion gals)
From 2004 to 2010	0.39	0.23	0.14	0.01	0.01	0.60
to 2020	2.51	1.47	0.93	0.06	0.05	4.97
to 2030	5.52	3.23	2.05	0.14	0.10	11.59

Figure 10.1 illustrates the typical pattern of national savings and costs resulting from standards over time. The heavy line running just below the energy and water savings bars indicates the undiscounted net national consumer impact of standards over time. Figure 10.1 shows the nature of net savings for the proposed rule relative to the baseline. This figure also illustrates that for the proposed two-tier standard most of the savings take place after the second tier becomes effective. Alternate standard levels would yield different values.

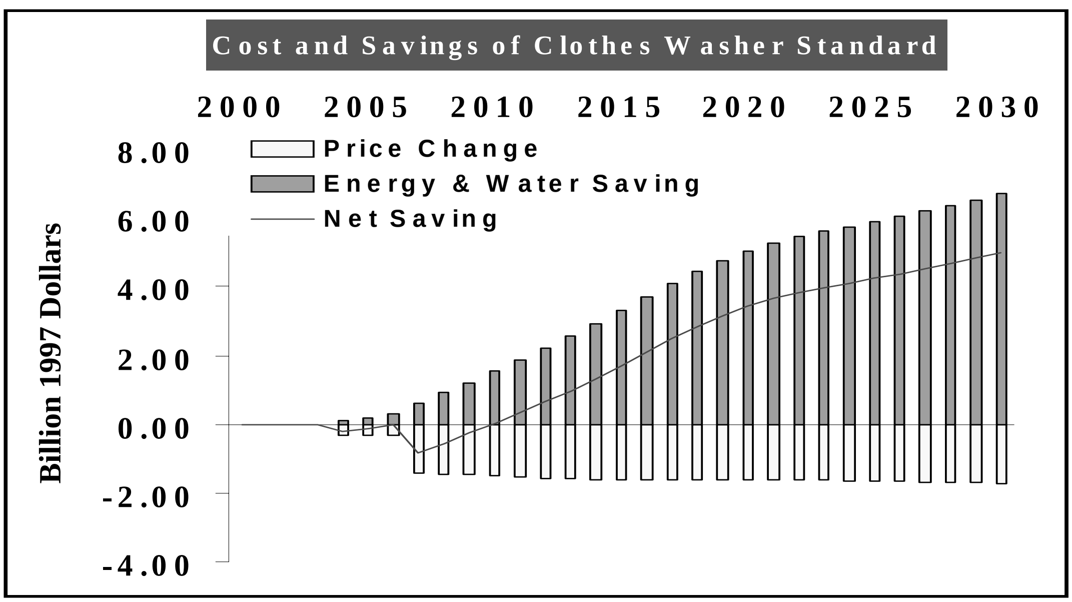

Figure 10.1 Annual Cost and Savings for the Proposed Clothes Washer Rule

10.5 USER INSTRUCTIONS FOR NES/SHIPMENTS SPREADSHEET

The clothes washer national energy savings (NES) and shipments spreadsheet is used to calculate the national energy, water and dollar savings from a clothes washer efficiency standard as well as to estimate future clothes washer shipments. The spreadsheet includes a clothes washer shipment model that uses clothes washer stock accounting together with a consumer decision model to forecast future shipments and sales. The consumer decision model includes probability functions that describe decisions regarding purchases, clothes washer repair, and breakdown information. The decision probabilities are used together with the accounting of purchases and stocks to forecast future clothes washer shipments under a variety of potential efficiency standards scenarios. The NES model uses input from the shipments model regarding washer purchases and compares the energy use between a baseline scenario and the various standards scenarios.

The 'Welcome NES' and 'Welcome Ship' worksheets act as the main user interfaces for NES and shipment forecast calculations respectively. When the user clicks on the 'Welcome NES' or 'Welcome Ship' tab, a user interface appears. For the NES scenario, this can be run for different standard levels and scenarios for energy price projection, start year, discount rate, annual h-axis market share increase, and water escalation rate. This worksheet also has a *Reset Base Case* button that allows the user to set the base case scenario. Similarly for the shipments forecast, different manufacturer price mark-ups, macro-economic explanatory variables, and consumer decision elasticities can be selected by the user.

10.5.1 BASIC OPERATING INSTRUCTIONS

Once you have downloaded the NES/Shipments integrated spreadsheet file from the web, open the file using Excel. At the bottom, click on the tab for the 'Welcome NES' or 'Welcome Ship' worksheet. The 'Welcome NES' worksheet will display two tables: Energy and Water Savings, and Cost and Net Present Values. Also included is a chart Cost and Savings of Clothes Washer Standard. Use Excel's commands at the top, View/Zoom, to change the size of the display to make it fit your monitor.

In the revised NES and shipments analysis, operating costs effect the base case shipments projection. Because of this, every time a parameter is changed, the base case scenario needs to be recalculated and saved for comparison with the standard case scenario.

Therefore, the first step in using the NES/Shipments spreadsheet is to set the base case. To do this you first select the Standard Case Design that you want to use for the base case scenario. Then you select the Energy Price Projection, Water Escalation Rate, Discount Rate, Start Year, and the Annual % Increase of H-Axis market share of interest. In addition, if you want to change options in the shipments model, you need to go to the 'Welcome Ship' worksheet and select the combination of markup and elasticities of interest. After you make these selections, the spreadsheet will calculate the shipments and the energy use characteristics of the base case scenario. Next click on the *<u>Reset Base Case</u>* button in the 'Welcome NES' worksheet in order to copy the data from the shipment forecast into the base case worksheet. Then, select the standard scenario that you wish to compare to the base case, and the spreadsheet will calculate the new forecast of shipments, energy use, and water use. It will also calculate the expenses and savings of the standard scenario in comparison to the base case that was set.

The following two tables provide the specific spreadsheet locations for several quantities mentioned in this documentation. Table 10.10 shows the quantities and their locations in the national energy savings spreadsheet (NES2000-0515-2T.XLS).

Table 10.10 National Energy Saving Quantities and their Locations in the National Energy Savings Spreadsheet

QUANTITY	SHEET	COLUMN	ROW
National Annual Energy Consumption	Base Case or Ship Forecast	BX-CM	58-113
National Annual Energy Savings	Savings	U	11-41
Source conversion factor (src_conv)	Energy Inputs	AJ-AK	54-84
Stock of clothes washers ($STOCK_V$)	Base Case or Ship Forecast	D-AG[a]	58-113
Cycles per year (n_{cycle})	Energy Inputs	V	54-84
Energy per Cycle (UEC)	Engineering	G-S	35-39

Table 10.11 Net Present Value Quantities and their Locations in the National Energy Savings Spreadsheet

QUANTITY	SHEET	COL	ROW
Discount factor	Savings	AG	11-67
Net Present Value (NPV)[b]	Welcome NES	S	12
Present Value of Costs (PVC)[c]	Welcome NES Savings (Original)	S AF	11 66
Present Value of Savings (PVS)[d]	(Copy) NES (Original) Savings	S AE	10 66
Net equipment Cost (yearly)	Savings	AC	15-41
Total Operating Cost Savings (yearly)	Savings	AD	15-41

[a] These columns may be hidden. To display them, use the Excel command sequence Format/Column/Unhide.

[b] Referred to in the spreadsheet as “net present benefit.”

[c] Referred to in the spreadsheet as “net equipment cost” (discounted).

[d] Referred to in the spreadsheet as “total energy and water savings” (discounted).

REFERENCES

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2. *Title 10, Code of Federal Regulations, Appendix J1 to Subpart B or Part 430--Uniform Test Method for Measuring the Energy Consumption of Automatic and Semi-automatic Clothes Washers,* January 1, 1999, U.S. Office of the Federal Register.

3. Lawrence Berkeley National Laboratory, *Draft Report on the Preliminary Engineering Analysis for Clothes Washers, Appendix D-1,* October, 1996. Berkeley, CA. Report to U.S. Department of Energy, Office of Codes and Standards.

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